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(71) Applicant
Glaverbel (Belgium),
Chaussee de La Hulpe 166, Watermael-Boitsfort, Belgium

(72) Inventor
Camille Dupont

(74) Agent and/or Address for Service
Hyde Heide & O'Donnell,
140 Buckingham Palace Road, London, SW1W 9TR

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(58) Field of search
C1M

(54) Coloured soda-lime glass

(57) In order to provide coloured soda-lime glass, at least three of iron, selenium, cobalt, nickel, chromium and manganese are present in the glass as colouring agents, in amounts corresponding to the following percentage proportions by weight of the glass

Fe ₂ O ₃	0.2	to	0.5
Se	0.0015	to	0.0120
Co	0	to	0.0020
Ni	0	to	0.0120
Cr ₂ O ₃	0	to	0.0220
MnO	0	to	0.4000

The sum: the amount of any Cr₂O₃ present in the glass plus ten times the amount of any Co present in the glass is at least 0.0100% by weight of the glass, and the proportions of the colouring agents are such that the resulting glass has the following light transmitting properties (as indicated on the CIE colour diagram).

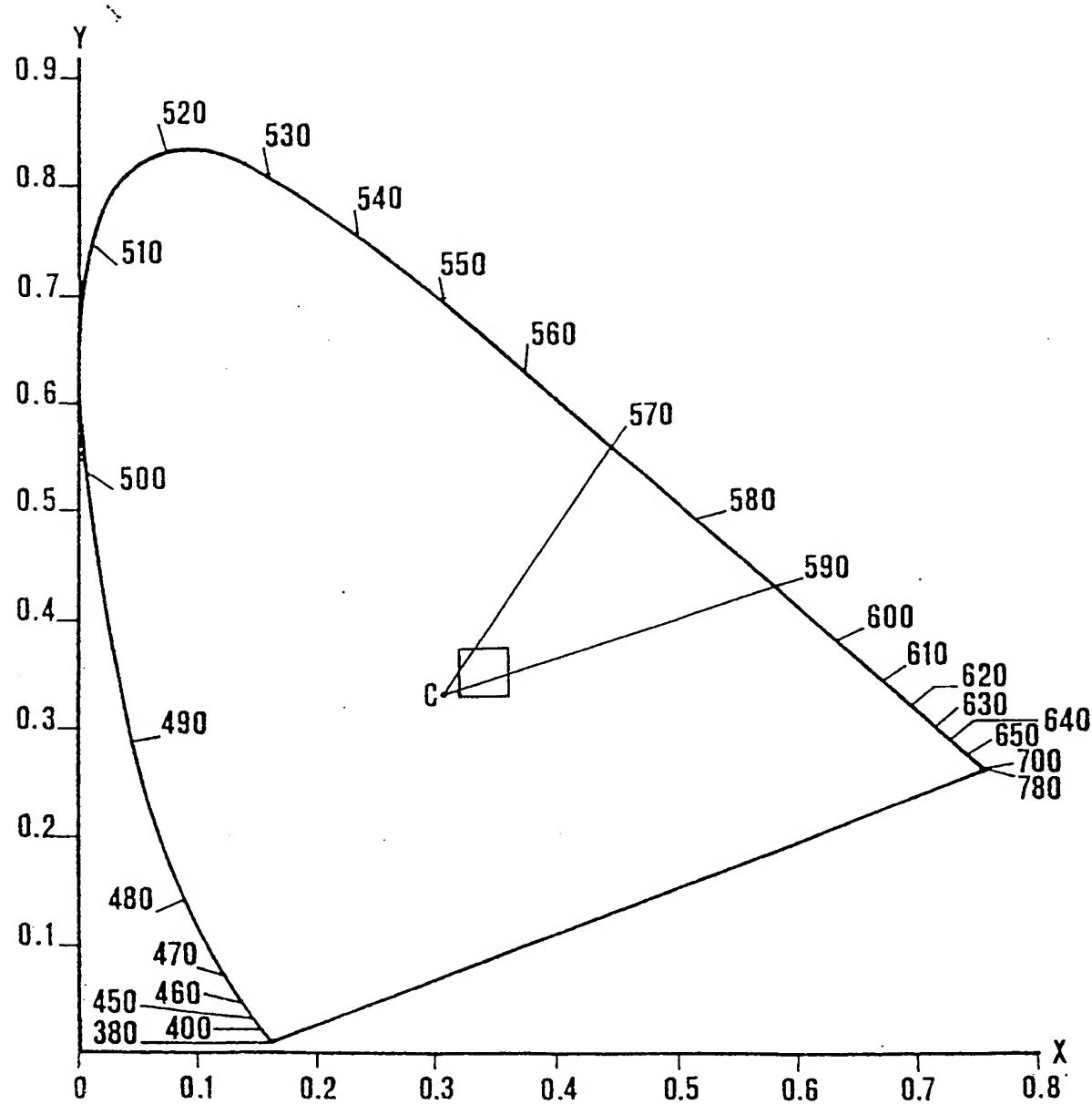
Purity of excitation	between 12% and 22%
Dominant wavelength	between 576nm and 584nm
Visible light transmission factor	at least 55%

GB 2 162 835 A

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FIG. 1



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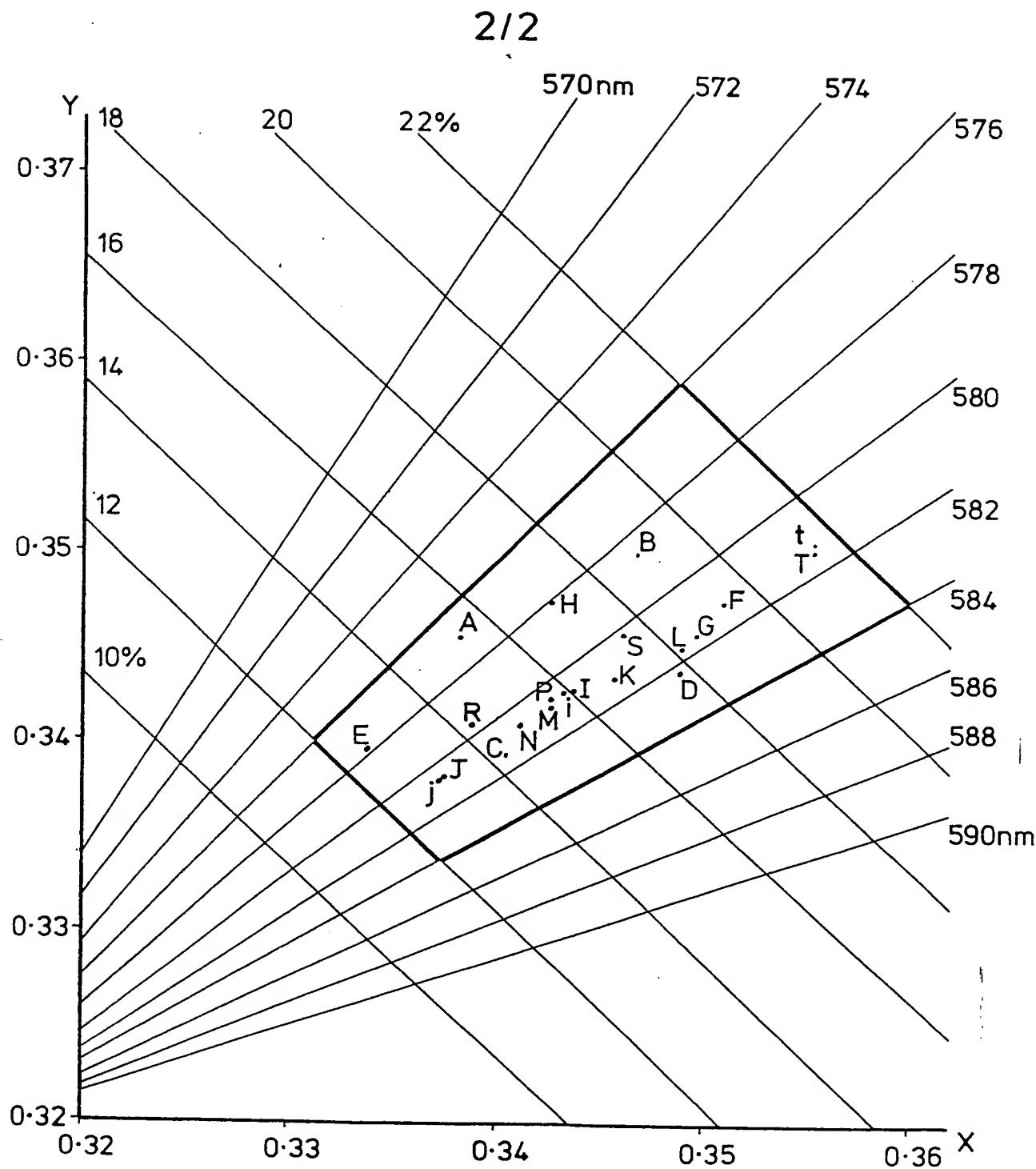


FIG. 2

SPECIFICATION

Coloured soda-lime glass

5 This invention relates to coloured soda-lime glass comprising a base composition of main glass forming constituents together with colouring agents. 5

The expression "soda-lime glass" is used herein in a broad sense, and denotes any glass which contains by weight the following glass forming constituents

10	SiO ₂	60%	to	75%	10
	Na ₂ O	10%	to	20%	
	CaO	0%	to	16%	
	K ₂ O	0%	to	10%	
	MgO	0%	to	10%	
15	Al ₂ O ₃	0%	to	5%	15
	BaO	0%	to	2%	
	BaO + CaO + MgO	10%	to	20%	
	K ₂ O + Na ₂ O	10%	to	20%	

20 When discussing the optical properties of a glass sheet it is in general necessary to relate those properties to a standard source of illumination. For the purposes of this specification, Illuminant C established by the International Commission on Illumination (CIE) is used as the standard source of illumination. Illuminant C is nominally an average daylight source having a colour temperature of 6700K. The International Commission on Illumination has also published "Colorimetry, Official Recommendations of the International Commission on Illumination" (May, 1970) which sets out a theory of colorimetry according to which colour co-ordinates for light of each wavelength within the visible spectrum are defined so that they may be represented diagrammatically on a graph having orthogonal X and Y axes to form what is known as the CIE colour diagram. This colour diagram is reproduced as Figure 1 of this specification. Figure 1 shows the locus for light of each wavelength (expressed in nanometres) within the visible spectrum. This is known as the spectrum locus, and light whose colour co-ordinates place it on the spectrum locus is said to have 100% purity of excitation of the appropriate wavelength. The spectrum locus is closed by a line known as the purple line which joins the co-ordinate positions on the spectrum locus for wavelengths of 380nm (violet) and 780nm (red). The area enclosed by the spectrum locus and the purple line is the field available for the possible colour co-ordinates of any visible light. The colour co-ordinates of the light emitted by Illuminant C are also plotted on Figure 1 at point C. Point C (0.3101; 0.3163) is taken to represent white light and accordingly has zero purity of excitation of colour of any wavelength. It will readily be appreciated that lines can be drawn from point C to the spectrum locus at any desired wavelength, and that any point lying on such a line can be defined not only in terms of its X;Y co-ordinates, but also in terms of the wavelength line on which it lies and its distance from point C relative to the total length of that wavelength line. Thus light transmitted by a sheet of coloured glass can be described in terms of this dominant wavelength and its purity of excitation expressed as a percentage. 30

35 In fact the CIE co-ordinates of light transmitted by a coloured glass sheet will depend not only on the composition of the glass, but also on the thickness of the sheet. Throughout this specification, including the claims, any values given for the colour co-ordinates (X;Y), the purity of excitation Pe% and the dominant wavelength λ_d of the transmitted light, and the visible light transmission factor of the glass (LT) are all calculated from the specific internal transmission (SIT) of a glass sheet 5mm in thickness. The specific internal transmission of a glass sheet is governed solely by the absorption of the glass and can be expressed according to the Beer-Lambert law, for a sheet 5mm in thickness as $SIT = e^{-a \cdot 5}$ where a is the 40 coefficient of absorption of the glass (cm^{-1}). As a first approximation, SIT can also be represented by the formula

$$(I_3 + R_2) / (I_1 - R_1)$$

where: I_1 is the intensity of visible light incident on a first face of the glass sheet; R_1 is the intensity of visible light reflected by that face; I_3 is the intensity of visible light transmitted from the second face of the glass sheet; and R_2 is the intensity of visible light reflected internally by that second face. 55

The present invention relates in particular to the composition of so-called bronze glasses.

Many compositions are known for forming bronze glasses having a dominant wavelength λ_d somewhere between 570nm and 590nm.

In general, known bronze glasses have been formulated for their solar screening properties, and their 60 use in glazing facades of modern buildings is familiar to many. For examples of such known glasses, reference may be had to U.S. Patent 4,104,076 (Saint- Gobain Industries, corresponding to French Patent 2,082,459). As stated in that Patent, it is highly desirable for architectural purposes that the purity of excitation of light transmitted by a window made of such glass should not be too high in order to retain a relative neutrality in the luminous ambience, and accordingly the purity of excitation should be limited to 65 14%. In order to achieve the required degree of solar screening, a 6.2mm thick sheet of the glass should

transmit less than 50% of incident solar energy, and the factor of luminance must be limited in order to achieve this end, but should be high enough to preserve an agreeable aspect and admit enough light in dull weather. Thus for bronze glass, the factor of luminance should be between 40% and 55%.

Other formulations for producing bronze glasses with special properties have also been proposed. For example in their Belgian Patent No. 848,372, Saint-Gobain Industries propose glasses having a factor of 5 luminance of 45% to 60%, a total solar energy transmission factor of 35% to 55%, a dominant wavelength λ_d of between 578nm and 583nm, and a purity of excitation P_e of between 20% and 35%, preferably at least 25%, to be used for glazing buildings, especially shop windows, where a high degree of heat and ultra-violet shielding is required.

10 The present invention is concerned to provide bronze glass which is especially suitable for use in glazed furniture and which in particular may be used to form shelves in display or other cabinets. For such purposes, it is important that the glass of the thickness actually to be used should transmit a relatively high proportion of incident light. Glass to be used for shelving usually needs to be two to three times as thick as that used for window glazing, and it has been found difficult to reconcile this requirement for high transmissivity with the achievement of a good colour and depth of colour so as to give 15 tonal harmony with various woods which is also important.

It is an object of the present invention to provide a range of compositions for the manufacture of bronze glasses which meet the desiderata referred to.

According to the present invention, there is provided coloured soda-lime glass comprising a base composition of main glass forming constituents together with colouring agents, characterised in that at least 20 three of iron, selenium, cobalt, nickel, chromium and manganese are present in the glass as colouring agents in amounts corresponding to the following percentage proportions by weight of the glass

25	Fe ₂ O ₃	0.2	to	0.5	25
	Se	0.0015	to	0.0120	
	Co	0	to	0.0020	
	Ni	0	to	0.0120	
	Cr ₂ O ₃	0	to	0.0220	
	MnO	0	to	0.4000,	

30 the sum: the amount of any Cr₂O₃ present in the glass plus ten times the amount of any Co present in the glass being at least 0.0100% by weight of the glass, and the proportions of the colouring agents being such that the resulting glass has the following light transmitting properties

35	Purity of excitation	between 12% and 22%	35
	Dominant wavelength	between 576nm and 584nm	

40 Visible light transmission factor at least 55%.

Glass according to the present invention has good transmissivity and colour for the purposes particularly in view.

In fact, glass having broadly similar colour properties, at and below the lower end of the dominant wavelength range given, can be produced by using nickel as sole or main colouring agent, the nickel being present in amounts of about 0.1% by weight of the glass. The presence of such large quantities of nickel is, however, disadvantageous especially if the glass is to be produced by the float process. In the float process a glass ribbon is led along the surface of a bath of molten tin while hot so that its surfaces become substantially truly flat and parallel. In order to prevent oxidation of the tin at the surface of the bath which would lead to tin oxide being picked up by the ribbon, a reducing atmosphere is maintained 45 above the bath. When the glass contains such a high proportion of nickel, this will be partly reduced by the atmosphere above the tin bath giving rise to an unacceptable haze in the glass produced. This disadvantage is not apparent, or not so apparent, when the proportion of nickel in the glass is limited to 0.0120% as in the present invention, so glass according to the present invention can be formed into sheets by the float process as well as by any of the classical drawing processes. Of course glass according 50 to the present invention can also be formed into other products, for example hollow-ware.

In some preferred embodiments of the invention, Cr₂O₃ is substantially absent and Co is present in the glass in an amount of at least 0.0010% by weight of the glass. This allows the visible light transmission factor of the glass to be reduced in embodiments of the invention where this is desired. This is because the addition of cobalt within the range of amounts specified allows the addition of greater quantities of iron and selenium, again within the limits specified, without making any large alteration in the position 55 on the CIE diagram.

The reason for this is that the colouring effect of cobalt can be arranged approximately to balance that of iron and selenium. In fact the colouring effects of the various colouring agents envisaged for use in a glass according to the invention are as follows ('Le Verre', Horst Scholze, Trans. J. Le Dû, Institut du Verre, Paris 1969).

Iron. Iron is in fact present in almost all commercially produced glass, either as an impurity, or as a deliberately introduced colouring agent. The presence of Fe^{3+} ions in glass gives rise to slight absorption of short wavelength visible light and to a very strong absorption band in the ultra-violet region, while the presence of Fe^{2+} ions gives rise to strong absorption in the infra-red. Ferric iron imparts a mild yellow

5 colouration to the glass, while ferrous iron gives a stronger greenish-blue colour.

5

Selenium. The Se^{4+} cation has practically no colouring effect, whereas the uncharged Se^0 element imparts a pink colouration. The Se^{2-} anion forms a chromophore with any ferric ions present, and this gives a brownish red colour to glass.

10 *Cobalt.* The group $[Co^{2+}O_4]^{2-}$ produces an intense blue colouration giving a dominant wavelength almost opposite to that imparted by the presence of the iron - selenium chromophore.

10

Nickel. The group $[Ni^{2+}O_4]$ gives rise to a blue colouration, and the group $[Ni^{3+}O_6]$ to a yellow colouration of the glass.

10

15 *Chromium.* The presence of the coordinate $[Cr^{3+}O_6]$ gives rise to absorption bands at 650nm to give a clear green colour. Strong oxidation gives rise to the coordinate $[Cr^{6+}O_4]$ which gives a very intense absorption band at 365nm giving a yellow colouration.

15

Manganese. Mn^{2+} ions have practically no colouring effect, and this is the usual state in which manganese appears in glass. However in a glass rich in alkali metal ions, the group $[Mn^{3+}O_6]$ appears and this provokes a violet colour.

20 In the most preferred embodiments of the invention, MnO is present in the glass in an amount of at least 0.0400% by weight of the glass. That the addition of such large quantities of manganese should be desirable is extremely surprising. It has hitherto been thought that the addition of substantial quantities of manganese would lead to undesirable solarization effects. Because manganese has only a very slight colouring effect when added to ordinary soda-lime glass, it would be expected that there would be no point in adding manganese. However it has now been found that such quantities of manganese can be

20

25 added without solarization and with considerable advantage. The addition of such quantities of manganese appears to have an indirect effect on the formation of the iron - selenium chromophore. It is presently believed that this is because addition of manganese has a stabilising effect on the partial pressure of oxygen in the glass. But whether this be true or not, the fact remains that due to the presence of such quantities of manganese, the formation of the iron-selenium chromophore is less affected by

25

30 changes in the melting conditions, in particular the atmosphere within the glass melting furnace, and this gives considerable practical advantages.

30

The possession of favourable properties for the purposes primarily in view is promoted when one or more of the following preferred optional features is adopted.

I Cr_2O_3 is present in the glass in an amount of at least 0.0120% by weight of the glass and Co is present in the glass in an amount of 0 to 0.0015% by weight of the glass. Such a glass presents a greenish tint which harmonises particularly well with certain woods such as mahogany.

35

II the purity of excitation of light transmitted by the glass is at most 20%, and is preferably at most 18%. A purity of excitation within such limit presents a more neutral aspect.

III Cr_2O_3 is substantially absent from the glass, Ni is present in an amount between 0.0030% and 40 0.0115% by weight of the glass, Se is present in an amount between 0.0040% and 0.0080% by weight of the glass, and the purity of excitation of light transmitted by the glass is at least equal to 16%. Such glasses have a warm tone which harmonises well with woods of a pale colouration.

40

IV Se is present in an amount between 0.0030% and 0.0080% by weight of the glass. with such quantities of selenium, it is possible to impart a warm tone to glass in an economical manner. Selenium is a costly ingredient and large quantities of selenium added to the batch will not in fact be incorporated into the glass. Within the range given, selenium can be incorporated in the glass without too much wastage.

45

V Ni is present in the glass in an amount of at least 0.0080% by weight of the glass. The adoption of this feature allows the proportion of Cr_2O_3 to be reduced or eliminated while maintaining a given colour: increasing the Ni content accentuates the colour and permits harmonisation with various colours of wood.

50

VI the glass gives a dominant wavelength between 580nm and 584nm to light transmitted thereby. Such glass has a relatively neutral brownish tint: its colouring is less appreciable for a given purity of excitation.

55 The present invention will now be described in greater detail with reference to the accompanying drawings, in which:

55

Figure 1 is a reproduction of the basic CIE colour diagram, and

Figure 2 is a detail to larger scale of part of that diagram.

60 In Figure 1, the curved spectrum locus on which lie the co-ordinate points of light having purity of excitation $P_e = 100\%$ of all visible dominant wavelengths λ_d from 380nm to 780nm and the straight purple line joining the end points of the spectrum locus have already been described, as has the location of point C which represents white light having purity of excitation $P_e = 0$ for all wavelengths. Also shown on Figure 1 are dominant wavelength lines of 570nm and 590nm, and a rectangle which represents the area of the diagram shown to larger scale in Figure 2.

60

65 In Figure 2 are shown several dominant wavelength lines between 570nm and 590nm, and various loci of constant purity of excitation P_e s between 10% and 22%. The field defined in claim 1,

65

Purity of excitation P_e between 12% and 22%
 Dominant wavelength λ_d between 576nm and 584nm

5 is also outlined.

Figure 2 also shows co-ordinate points of various examples of glass in accordance with the invention of which further details are given in the following tables. The points indicated by lower case letters *i*, *j* and *t* correspond to Examples I, J and T after solarisation.

There now follow certain specific examples of glass compositions according to this invention.

10 The following table 1 shows base glass compositions of the various Examples, and tables 2 to 5 show: 10

I Batch compositions of glass formers for melting to produce glass according to the invention. Quantities of materials indicated are in tonnes for producing 1000 tonnes of glass.

II Colourants to be added to the batch. Quantities of materials indicated are in kilogrammes for producing 1000 tonnes of glass. In fact the colourants are not necessarily added in the form shown. It is

15 however convenient and conventional to give the quantities of colouring ingredients added as their molar equivalents in the forms shown. 15

III Proportions by weight of colouring agents in the glass produced, determined by X-ray fluorescence analysis of the glass and converted to the molecular species indicated.

IV An indication of the optical properties of the glass produced in terms of X;Y coordinates on the CIE 20 colour diagram, the dominant wavelength λ_d nm and the purity of excitation P_e % of light transmitted by 20

25 colour diagram, the dominant wavelength λ_d nm and the purity of excitation P_e % of light transmitted by the glass, and the visible light transmission factor of the glass, all calculated from the specific internal transmission of a 5mm thick glass sheet. 25

V An indication of the optical properties of some of the Examples of glass produced after they have been subjected to a solarising treatment. This treatment consisted of irradiating specimens of the glass 25 for a specified number of hours using a 125 watt Philips HPR lamp.

TABLE 1

30 Base glass analysis (% by weight)				
	Example	A to G	H,I,J,N,P,R	K,L,M,S,T
35	SiO ₂	72.45	71.5	70.8
	Al ₂ O ₃	1.55	1.55	0.9
	CaO	8.05	8.05	8.7
	MgO	4.0	4.0	4.7
	Na ₂ O	13.2	14.2	14.1
	K ₂ O	0.1	0.1	0.2
	SO ₃	Balance	Balance	Balance

TABLE 2

	EXAMPLE	A	B	C	D	E	
5	GLASS FORMERS (tonnes)						5
	sand	682.17	682.17	682.17	682.17	682.17	
	feldspar	71.1	71.1	71.1	71.1	71.1	
	limestone	42.2	42.2	42.2	42.2	42.2	
	dolomite	185.9	185.9	185.9	185.9	185.9	
10	Na ₂ CO ₃	195.2	195.2	195.2	195.2	195.2	10
	sulphate	13.0	13.0	13.0	10.0	10.0	
	nitrate	11.25	11.25	11.25	15.0	15.0	
	COLOURANTS (kg) calculated as:						
15	Fe ₂ O ₃	3000	3000	3000	3000	3000	15
	CoO	0	0	17	17	17	
	NiO	38	63.5	38	38	38	
	Se	225	750	225	750	750	
20	K ₂ Cr ₂ O ₇	241	241	0	0	135	20
	MnO ₂	0	0	0	0	0	
	COLOURING AGENTS (% by weight in glass after analysis calculated as)						
	Fe ₂ O ₃	0.365	0.365	0.363	0.372	0.373	
25	Co	-	-	0.0010	0.0010	0.0011	25
	Ni	0.0039	0.0043	0.0028	0.0036	0.0028	
	Se	0.0029	0.0041	0.0035	0.0058	0.0034	
	Cr ₂ O ₃	0.0137	0.0123	Traces	-	0.0070	
	MnO	-	-	-	-	-	
30	X	0.3382	0.3467	0.3400	0.3488	0.3339	30
	Y	0.3456	0.3500	0.3396	0.3439	0.3395	
	λ ₀ nm	577	578.7	580.7	582.3	577.9	
	Pε %	15.4	18.9	14.3	17.8	12.6	
	LT%	70.76	66.98	65.21	62.45	68.33	

TABLE 3

	EXAMPLE	F	G	H	I	J	
5	GLASS FORMERS (tonnes)						5
	sand	682.17	682.17	672.17	672.17	672.17	
	feldspar	71.1	71.1	71.1	71.1	71.1	
	limestone	42.2	42.2	42.2	42.2	42.2	
	dolomite	185.9	185.9	185.9	185.9	185.9	
10	Na ₂ CO ₃	197.1	195.2	211.5	211.5	211.5	10
	sulphate	7.5	10.0	13.3	13.3	13.3	
	nitrate	15.0	15.0	13.3	13.3	13.3	
15	COLOURANTS (kg) calculated as						15
	Fe ₂ O ₃	3000	3000	2310	1810	1400	
	CoO	17	17	17	17	17	
	NiO	38	90	114	114	114	
	Se	520	375	525	525	375	
	K ₂ Cr ₂ O ₇	96		241			
20	MnO ₂				1220	1220	20
25	COLOURING AGENTS (% by weight in glass after analysis calculated as)						25
	Fe ₂ O ₃	0.360	0.362	0.302	0.254	0.214	
	Co	0.0011	0.0010	0.0009	0.0010	0.0010	
	Ni	0.0031	0.0059	0.0082	0.0102	0.0100	
	Se	0.0075	0.0051	0.0035	0.0055	0.0042	
	Cr ₂ O ₃	0.0054		0.0126			
	MnO				0.1020	0.1000	
30	X	0.3509	0.3496	0.3425	0.3435	0.3375	30
	Y	0.3475	0.3458	0.3475	0.3428	0.3383	
	λ ₀ nm	581.3	581.6	578.1	580.8	580.6	
	Pε %	19.3	18.5	17.1	16.09	13.28	
	LT %	61.42	60.90	62.44	64.33	67.47	
35	And after solarisation				(i)	(j)	
	time (hours)				167	167	
	X				0.3432	0.3374	
	Y				0.3427	0.3381	
40	λ ₀ nm				580.7	580.6	40
	Pε %				15.9	13.15	
	LT %				63.95	67.19	

TABLE 4

	EXAMPLE	K	L	M	N	P	
5	GLASS FORMERS (tonnes)						5
	sand	682.17	682.17	682.17	672.17	672.17	
	feldspar	35.06	35.06	35.06	79.9	79.9	
	limestone	32.52	32.52	32.52	42.2	42.2	
	dolomite	223.48	223.48	223.48	185.9	185.9	
10	Na ₂ CO ₃	212.05	212.05	212.05	211.5	211.5	10
	sulphate	11.73	11.73	11.73	13.3	13.3	
	nitrate	12.05	12.05	12.05	13.3	13.3	
	COLOURANTS (kg) calculated as						
15	Fe ₂ O ₃	2310	2310	2310	1810	1810	15
	CoO	19	19	19	17	17	
	NiO	127	127	127	114	114	
	Se	300	525	150	525	525	
20	K ₂ Cr ₂ O ₇	-	-	-	-	-	20
	MnO ₂	-	-	-	2440	3660	
	COLOURING AGENTS (% by weight in glass after analysis calculated as)						
	Fe ₂ O ₃	0.302	0.307	0.301	0.263	0.252	
25	Co	0.0013	0.0013	0.0013	0.0011	0.0011	25
	Ni	0.0102	0.0108	0.0115	0.0095	0.0085	
	Se	0.0048	0.00645	0.0039	0.0075	0.0078	
	Cr ₂ O ₃	-	-	-	-	-	
	MnO	Traces	Traces	-	0.1830	0.2630	
30	X	0.3456	0.3489	0.3426	0.3411	0.3426	30
	Y	0.3435	0.3452	0.3420	0.3410	0.3424	
	λ ₀ nm	581.2	581.7	580.8	580.7	580.6	
	Pe %	16.84	18.18	15.63	14.94	15.75	
	LT %	60.52	59.18	62.82	65.56	65.01	

TABLE 5

	EXAMPLE	R	S	T	
5	sand	672.17	682.17	682.17	5
	feldspar	79.9	35.06	35.06	
	limestone	42.2	32.52	32.52	
	dolomite	185.9	223.48	223.48	
	Na_2CO_3	211.5	212.05	212.05	
10	sulphate	13.3	11.73	11.73	10
	nitrate	13.3	12.05	12.05	
COLOURANTS (kg) calculated as					
15	Fe_2O_3	1810	2310	3000	15
	CoO	17	19	17	
	NiO	114	127	114	
	Se	525	375	375	
	$\text{K}_2\text{Cr}_2\text{O}_7$	4880	1220	488	
COLOURING AGENTS (% by weight in glass after analysis calculated as)					
20	Fe_2O_3	0.255	0.308	0.353	
	Co	0.0011	0.0012	0.0014	
	Ni	0.0092	0.0109	0.0084	
	Se	0.0066	0.0060	0.0070	25
	Cr_2O_3	-	-	-	
25	MnO	0.3630	0.1030	0.0450	
	X	0.3388	0.3460	0.3553	
	Y	0.3410	0.3458	0.3503	30
	$\lambda_0\text{nm}$	579.6	580.3	581.6	
	Pe %	14.35	17.56	21.26	
30	LT %	65.86	62.18	56.18	
	And after solarisation				35
	time (hours)		(t)		
	X		119		
	Y		0.3553		
35	$\lambda_0\text{nm}$		0.3507		
	Pe %		581.4		
	LT %		21.38		40
			56.12		
CLAIMS					
40	45 1. Coloured soda-lime glass comprising a base composition of main glass forming constituents together with colouring agents, characterised in that at least three of iron, selenium, cobalt, nickel, chromium and manganese are present in the glass as colouring agents in amounts corresponding to the following percentage proportions by weight of the glass				
	Fe_2O_3	0.2	to	0.5	45
	Se	0.0015	to	0.0120	
	Co	0	to	0.0020	
	Ni	0	to	0.0120	
45	Cr_2O_3	0	to	0.0220	
	MnO	0	to	0.4000	50
	50 the sum: the amount of any Cr_2O_3 present in the glass plus ten times the amount of any Co present in the glass being at least 0.0100% by weight of the glass, and the proportions of the colouring agents being such that the resulting glass has the following light transmitting properties				
	Purity of excitation	55 between 12% and 22%			
	Dominant wavelength	between 576nm and 584nm			
55	Visible light transmission factor	60 at least 55%.			

2. Glass according to claim 1, wherein Cr_2O_3 is substantially absent and Co is present in the glass in an amount of at least 0.0010% by weight of the glass.

3. Glass according to claim 1, wherein Cr_2O_3 is present in the glass in an amount of at least 0.0120% by weight of the glass and Co is present in the glass in an amount of 0 to 0.0015% by weight of the glass.

4. Glass according to any preceding claim, wherein the purity of excitation of light transmitted by the glass is at most 18%.

5. Glass according to any preceding claim, wherein MnO is present in the glass in an amount of at least 0.0400% by weight of the glass.

10 6. Glass according to any preceding claim, wherein Cr_2O_3 is substantially absent from the glass, Ni is present in an amount between 0.0030% and 0.0115% by weight of the glass, Se is present in an amount between 0.0040% and 0.0080% by weight of the glass, and the purity of excitation of light transmitted by the glass is at least equal to 16%.

15 7. Glass according to any preceding claim, wherein Se is present in an amount between 0.0030% and 0.0080% by weight of the glass.

8. Glass according to any preceding claim, wherein Ni is present in the glass in an amount of at least 0.0080% by weight of the glass.

9. Glass according to any preceding claim, wherein the glass gives a dominant wavelength between 580nm and 584nm to light transmitted thereby.

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